

WRITE-ONCE OPTICAL RECORDING MEDIUM AND DEFECT  
MANAGEMENT INFORMATION MANAGEMENT  
METHOD THEREOF

**[0001]** This application claims the priority benefit of the Korean Application Nos. P2003-010925 filed on February 21, 2003, P2003-013200 filed on March 3, 2003 and P2003-023876 filed on April 16, 2003, which are hereby incorporated by reference.

**BACKGROUND OF THE INVENTION**

**Field of the Invention**

**[0002]** The present invention relates to a write-once optical recording medium, a method and apparatus for managing defect management information thereof, and more particularly, to a method and device for allocating a temporary defect management area, a method for allocating a spare area for defect management, and a write-once optical recording medium on which the temporary defect management area and the spare area are allocated on a type of the optical recording medium such as a write-once blu-ray disc.

**Discussion of the Background Art**

**[0003]** Optical discs, which are a kind of optical recording media, can record a large amount of data, and are now being widely used. Currently, a kind of innovative high-density digital versatile disc (HD-DVD) such as blue ray disc (Blu-ray Disc) is under development. This

kind of medium can record and store video data of high quality and audio data of high fidelity for a long time.

**[0004]** The Blu-ray disc is a next generation optical recording solution that can store a larger amount of data than a conventional DVD.

**[0005]** The Blu-ray disc generally employs a blue-violet laser having a wavelength of 405nm. This wavelength is shorter than a red laser used on a conventional DVD. The wavelength of the red laser is 650 nm. The Blu-ray disc has a thickness of 1.2 mm and a diameter of 12 cm, and includes a light transmission layer having a thickness of about 0.1 mm. Therefore, the Blu-ray disc can store a larger amount of data than a conventional DVD.

**[0006]** An optical disc device for writing and reading data on the Blu-ray disc is shown in FIG. 1. It includes an optical pick-up 11 for writing and reading a signal on/from an optical disc 10, a video disc recorder (VDR) system 12 for processing the signal read out from the optical pick-up 11 into a replay signal, or for modulating and processing an externally inputted data stream into a record signal suitable for recording, and an encoder 13 for encoding an externally inputted analog signal and outputting the encoded analog signal to the VDR system 12.

**[0007]** A Blu-ray disc can be of a rewritable type, which is referred to herein as a Blu-ray Disc Rewritable (BD-RE). A BD-RE has a rewritable capability, which enables video and audio data to be written, erased, and rewritten thereon repeatedly. The BD-RE (shown in FIG. 2) is divided into a lead-in area (LIA), a data area and a lead-out area (LOA), and the front

and the rear of the data area are allocated to have an inner spare area (ISA) and an outer spare area (OSA).

**[0008]** With the BD-RE configured in the manner described above, the VDR system 12 of the optical disc device shown in FIG.1 encodes and modulates externally inputted data into a signal suitable for recording, and records by cluster unit corresponding to error correction block unit. If a defective area occurs in the data area while recording data on the BD-RE, the data of one cluster unit recorded on the defective area is also recorded on the spare area (for example, the inner spare area on the BD-RE) according to a linear replacement operation. A series of linear replacement operations can be performed.

**[0009]** Accordingly, the VDR system 12 of the optical disc device records the data of the cluster unit recorded on the defective area onto the spare area, even if the defective area occurs in the data area of the rewritable Blu-ray disc. When a playback operation is performed for the rewritable Blu-ray disc, the data recorded onto the spare area are read out and replayed so that a data recording error can be prevented.

**[0010]** Various standards related to the Blu-ray disc are under development.

**[0011]** In this respect, a second type of Blu-ray disc, on which data is not repeatedly rewritten (non-rewritable), but is written only once, is herein referred to as a Blu-ray Disc Write-Once (BD-WO).

**[0012]** The Write-once Blu-Ray disc is useful when it is not desirable to repeatedly rewrite data. In a BD-WO, management of defective areas is needed.

**[0013]** Since data can be recorded on the BD-RE repeatedly (due to the characteristics of the BD-RE), the size of the defect management area (DMA) for the rewritable Blu-ray disc is relatively small (see DMA1-DMA4 in FIG.2). In contrast, since data is recorded on the write-once Blu-ray disc only one time, the area required to manage the defective area for the BD-WO needs to be larger than the area required for the BD-RE. Accordingly, a sufficiently sized defect management area should be allocated for the BD-WO.

**[0014]** An effective defect management method for a BD-WO requires consistency and compatibility with standards that are applicable to the BD-RE, including consistency and compatibility related to recording and replaying of management information in order to obtain more efficient, more stable and higher performance in recording and replaying information and data. Thus, an innovative method, apparatus and structure for both recording and management of defective areas and related information for the BD-WO are needed.

#### **SUMMARY OF THE INVENTION**

**[0015]** Accordingly, the present invention is directed to a write-once optical recording medium (BD-WO), a defect management information management method thereof, and an apparatus for implementing the

method, that substantially obviate one or more problems due to limitations and disadvantages of the background art.

**[0016]** Additional advantages, objects, and features of the invention will be set forth in part in the description which follows, and in part will become apparent to those having ordinary skill in the art upon examination of the following, or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

**[0017]** To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a method of managing defects on a write-once optical recording medium having at least one recording layer, the method comprising the steps of allocating at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size to the optical recording medium, respectively, and recording defect management information on the at least one temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

**[0018]** In another aspect of the present invention, an apparatus for managing defects on a write-once optical recording medium, the apparatus comprising means for allocating at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size to the optical recording medium,

respectively, and means for recording defect management information on the at least one temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

**[0019]** In another aspect of the present invention, a write-once optical recording medium having at least one recording layer comprises at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size, wherein defect management information is recorded on the at least one temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

**[0020]** It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0021]** The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention, and together with the description serve to explain the principle of the invention. In the drawings:

**[0022]** FIG. 1 illustrates a schematic configuration of an optical disc device of the Background Art;

**[0023]** FIG. 2 illustrates a configuration of a recording area of a BD-RE;

**[0024]** FIG. 3 illustrates a schematic configuration of an optical disc device for a BD-WO of the present invention;

**[0025]** FIG. 4 illustrates a configuration of a recording area of an optical recording medium according to an embodiment of the present invention;

**[0026]** FIG. 5 illustrates a configuration of a recording area of an optical recording medium according to another embodiment of the present invention;

**[0027]** FIG. 6 illustrates an example of a temporary or interim defect management area usage method of the present invention;

**[0028]** FIG. 7 illustrates another example of a temporary or interim defect management area usage method of the present invention;

**[0029]** FIG. 8 illustrates another example of a temporary or interim defect management information composition method of the present invention;

**[0030]** FIG. 9 illustrates another example of a temporary or interim defect management information composition method of the present invention;

**[0031]** FIG. 10 illustrates a configuration of TDDS and information contents according to an embodiment of the present invention; and

**[0032]** FIG. 11 is a table of comparison of DMA, TDMA and IDMA of the present invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[0033] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0034] Referring to FIG.3, an optical disc recording/reproducing device 20 for a Blu-ray write-once optical recording medium according to the present invention includes an optical pickup 22 for writing/reading data to/from an optical recording medium 21 such as a BD-WO, a pickup servo unit 23 for controlling the optical pickup 22 to maintain a distance between an objective lens in the optical pickup 22 and the optical recording medium 21 and for tracking a pertinent track, a data processor 24 for processing and providing input data to the optical pickup 22, an interface 25 for exchanging data with an external host 30, a memory 27 for storing information regarding defect management, and a microcomputer 26 for controlling the above units. All of the components of the device 20 are operatively coupled. The host 30 is connected to the interface 25 of the device 20 for recording/reproducing data to/from the optical recording medium 21 for exchange of commands and data.

[0035] When an optical recording medium such as a BD-WO is loaded, the device 20 loads information regarding defect management, such as DMA (defect management area) information, TDMA (temporary



defect management area) information and so on, into the memory 26 or other suitable storage. During operation, the memory 27 is updated in accordance with a defect management operation. The present method can be also implemented using the device shown in FIG.1 or other suitable devices or systems.

**[0036]** FIG. 4 illustrates a configuration of a recording area of a BD-WO according to the present invention. The BD-WO shown in FIG.4 has a structure of a single layer disc. Also, the BD-WO shown in FIG.4 includes a lead-in area, a data area and a lead-out area. A user data area is located in the data area. The lead-in and lead-out areas include final or permanent defect management areas (DMA1-DMA4). The arrows in each respective area are used as examples of a data recording direction.

**[0037]** A temporary defect management area (TDMA) according to the present invention is provided in the lead-in area of the BD-WO. Here, the TDMA can be distinguished from the defect management areas (DMA1, DMA2, DMA3, DMA4). Particularly, the temporary defect management area (TDMA) is an area of the BD-WO that is used to temporarily record and manage defect management information until the BD-WO is finalized. Afterward, the defect management information is recorded onto at least one of multiple defect management areas, for example, DMA1-DMA4 on a recording layer shown in FIG. 4. The BD-WO is considered to be finalized, e.g., when recording of data onto a user data area of the BD-WO has been completed. The TDMA provided in the lead-in area has a fixed size, for example, 2048 clusters.

**[0038]** The data area of the BD-WO shown in FIG.4 includes the user data area, an inner spare area ISA0 and an outer spare area OSA0. The entire inner spare area ISA0 is used as an area for linear replacement, i.e., a replacement area for storing data assigned to a defective area of the user data area. No TDMA is allocated to the inner spare area ISA0. The outer spare area OSA0 includes an interim defect management area (IDMA) as provided by an embodiment of the present invention. Here, the IDMA is distinguished from the TDMA having a fixed size in the lead-in area described above. In this regard, the IDMA is considered a temporary defect management area having a variable size. However, the TDMA and the IDMA may have the same contents despite the difference between the terms and/or may differ from each other depending on a manner in which the TDMA and IDMA are used with respect to various manners, times and/or events in the actual recording process. This will be discussed in more detail when the methods of using the TDMA and IDMA are discussed.

**[0039]** In the single layer BD-WO shown in FIG. 4, a portion of the outer spare area OSA0 is used as the IDMA and a remaining portion of the outer spare area OSA0 is used as an area for linear replacement (replacement area). For example, the IDMA is allocated to a portion adjacent to the replacement area of the OSA0. The size of the IDMA is variably allocated depending on the size of the spare area. Since the outer spare area (OSA0) has a variable size, the IDMA also has a variable size.

**[0040]** Here, the IDMA having a variable size is allocated to the data area, depending on whether or not there is a determination made to allocate a spare area. If an outer spare area is to be allocated, the IDMA may be allocated in the manner described above. If an outer spare area is not allocated, only the TDMA having a fixed size is allocated (IDMA is not allocated). In such a case, the TDMA is used to manage defect management information. In another example, even though the spare area OSA0 exists, the IDMA may still not be allocated according to a choice of design. This means that the designer has a wide variety of design choices with respect to allocation of the IDMA. However, if the spare area (e.g., OSA0) is allocated, in one embodiment both are generally always allocated together, that is, if OSA0 is allocated, the IDMA is allocated also in the OSA0.

**[0041]** The size of the IDMA positioned at the outer track of the disc depends on the size of the spare area OSA0 (the size of OSA0 is variable). For example, if the size of the spare area OSA0 is  $N \times 256$  ( $0 \leq N \leq 64$ ) clusters, the size of the IDMA can be varied to  $P \times 256$  clusters, where  $P = N/4$ .  $P$  and  $N$  may be integers. In other words, in the example set forth above, a method can be used (as an example) in which the size of the IDMA (having a variable size) is allocated by one-fourth the size of the outer spare area.

**[0042]** As an example, if  $N = 64$ , since the size of the outer spare area OSA0 is 16384 clusters and  $P = N/4 = 16$ , the size of the interim defect management area IDMA is 4096 clusters.

**[0043]** Similarly, the size of the IDMA positioned at an outer track area of the disc may have a size that is different from the example given above in that it is made to be variable depending on the size of the spare area OSA0. This is possible in a case which takes into consideration that when the area for linear replacement is reserved in the outer spare area OSA0, the size of the area for linear replacement, the size of the defect management area and the size of the spare area OSA0 all depend on one another. In comparison, the size of the inner track area, especially the size of the TDMA positioned at the lead-in area, has a fixed value.

**[0044]** In the embodiment shown in FIG.4, it is readily apparent that the TDMA is not positioned in the data area, but is positioned in the lead-in area. The interim defect management area IDMA is positioned in the outer spare area OSA0 and can be set to a size of '0'. In this case, the entire OSA0 would be used as a replacement area. In another case, the ISA0 and OSA0 can be allocated by a size of '0' if no defect management is to be performed. Nevertheless, since the TDMA of the lead-in area is available, specific information can be recorded and managed using a temporary disc definition structure (TDDS), even though a temporary defect list (TDFL) is not managed. A further explanation of the method in which the TDFL and TDDS is recorded (and used herein) will be provided later.

**[0045]** According to the present embodiment, if a defective area (e.g., the user data area) is created or discovered when data are recorded in the BD-WO, the data recorded (or to be recorded) on the defective area

is recorded on a predetermined area for linear replacement. A defective area may be created as a result of the recording process itself, or a defective area may be "discovered" while recording. In the latter case, a discovered defective area is not the result of the current recording process. In case of the created defect, the corresponding defect management information is recorded on both the temporary and interim defect management areas TDMA and IDMA.

**[0046]** FIG. 5 shows an embodiment of the present invention, which illustrates another configuration of a recording area of a BD-WO. The BD-WO shown in FIG. 5 has a structure of a dual layer disc. The BD-WO structure shown in FIG.5 includes a lead-in area, a data area 50a and an outer area (Outer Area 0) on a first recording layer (Layer 0), and a lead-out area, a data area 50b and an outer area (Outer Area 1) on a second recording layer (Layer 1).

**[0047]** The arrows in each area are examples which indicate a data recording direction.

**[0048]** In the dual layer BD-WO shown, however, the temporary defect management area (TDMA) of the present invention is provided in both the lead-in area and the lead-out area. The data areas 50a, 50b include inner spare areas ISA0 and ISA1 and outer spare areas OSA0 and OSA1 as shown. Each of the inner spare area ISA1 and the outer spare areas OSA0 and OSA1 includes an IDMA on each recording layer. In other words, an IDMA is allocated to each of the spare areas OSA0, OSA1

and ISA1, all having a variable size depending on the variable size of the spare area except for ISA0 (which may have a fixed size).

**[0049]** In this example, the TDMA provided in the lead-in area (first recording layer) and the lead-out area (second recording layer) of the dual layer BD-WO shown in FIG.5 has a fixed size, for example, 2048 clusters.

**[0050]** All of the inner spare area ISA0 is used as an area for linear replacement. In other words, an IDMA for temporary defect management is not allocated to the inner spare area ISA0.

**[0051]** Portions of the inner spare area ISA1 and the outer spare areas OSA0 and OSA1 are used as the IDMA, and the remaining portions (or other portions) of the inner spare area ISA1 and the outer spare areas OSA0 and OSA1 are used as areas for linear replacement of a defective area. In one example, IDMA's are allocated to a portion in the spare areas which is adjacent to an area for linear replacement. The size of the IDMA(s) is allocated depending on the size of the spare areas ISA1, OSA0 and OSA1 (these spare areas have a variable size).

**[0052]** Here, the IDMA's having a variable size are allocated to the data area depending on whether or not a determination is made to allocate the corresponding spare areas (spare area that corresponds to the particular IDMA). If the spare area is allocated, the IDMA's may be allocated as described above. If the spare areas are not allocated, only the TDMA's are allocated. Some or all of the lead-in area and/or the lead-out area may be used to store defect management information. As one example, if the size of the outer spare area OSA0, OSA1 is  $N \times 256$  ( $0 \leq N$

$\leq 32$ ) clusters and the size of the inner spare area ISA1 is  $L \times 256$  ( $0 \leq L \leq 64$ ) clusters, then the size of the interim defect management areas in the OSA0 and OSA1 can be varied to  $P \times 256$  clusters and the size of the interim defect management area in the ISA1 can be varied to  $Q \times 256$  clusters, where P and Q are determined to be  $P = N/4$  and  $Q = L/4$ . N and L may be integers. This method can be referred to as a method in which the size of the IDMA having a variable size is allocated by one-fourth the size of the corresponding outer or inner spare area OSA0, OSA1 or ISA1.

**[0053]** For example, if  $N = 32$ , since the size of the outer spare areas (OSA0 + OSA1) is 16384 clusters and  $P = N/4 = 8$ , the total size of the IDMA in the OSA0 and the IDMA in the OSA1 is 4096 clusters. If  $L = 64$ , since the size of the inner spare area ISA1 is 16384 clusters and  $Q = L/4 = 16$ , the size of IDMA in the ISA1 is 4096 clusters. Then the total size of all the interim defect management areas on the first and second recording layers is 8192 clusters.

**[0054]** Similarly, the size of the IDMA is made to be variable depending on the size of the spare areas ISA1, OSA0 and OSA1, taking into account that when the area for linear replacement is designed to be in the spare area, the size of the area for linear replacement, the size of the defect management area and the size of the spare area all depend on one another. In comparison, the size of the inner track area (especially the TDMA positioned at the lead-in area and the lead-out area) has a fixed value.

**[0055]** In the above embodiment having a dual layer BD-WO structure of the present invention, it is readily apparent that the TDMA is positioned in the lead-in area and also positioned in the lead-out area. The interim defect management areas IDMA positioned on the spare areas may have a size of '0' if all of the data area is used for user data recording. The spare areas may be allocated by a size of '0' if defect management is not performed. Nevertheless, since the TDMAs of the lead-in area and the lead-out area remain available for use, specific information can be recorded and managed using a temporary disc definition structure (TDDS) although a temporary defect list (TDFL) may not be managed. These will be explained in more detail later, but meanwhile, an IDMA having a size of "0" is an indication that the TDFL is not managed.

**[0056]** Also according to the embodiment shown in FIG. 5, if a defective area is created during the actual recording of data in the BD-WO, the data to be recorded on the defective area is recorded on a predetermined area for linear replacement. In such a case, the associated defect management information may be recorded on both the temporary and interim defect management areas TDMA and IDMA in the OSA0, OSA1 or ISA1.

**[0057]** In general, allocation of an IDMA depends on whether or not a determination is made to allocate a spare area. Once a determination is made to allocate a spare area, the method of allocating an IDMA



(employing the method of allocating a spare area and the method of managing a defect) will be applicable as described herein.

**[0058]** In addition to the discussion set forth above, there is also a case to be considered in which a spare area is not allocated in the dual layer BD-WO. Particularly, there is a case in which only the TDMA is used, and a case in which only the TDMA is used if only the inner spare area ISA0 is allocated. If the inner spare area ISA0 and outer spare areas OSA0 and OSA1 are allocated, the IDMAS in the OSA0 and OSA1 are allocated. If only the inner spare areas ISA0 and ISA1 are allocated but the outer spare areas OSA0 and OSA1 are not allocated, the interim defect management area IDMA in the ISA1 can be allocated. If all of the spare areas are allocated, the IDMA in the ISA1, OSA0 and OSA1 can all be allocated as described above.

**[0059]** FIG. 6 illustrates an example of a method of using temporary or interim defect management areas TDMA or IDMA in the single layer or dual layer BD-WO according to an embodiment of the present invention. In this method, the TDMA shows both TDDS and TDFL. However, although not shown in the illustration, the IDMA can also include both TDDS and TDFL. The embodiment shown in FIG. 6 illustrates that the particular defect management information (TDDS and TDFL) is recorded in the TDMA before it is recorded in the IDMA.

**[0060]** A discussion of TDDS and TDFL will now be provided. In the present invention, TDDS refers to temporary disc definition structure and is distinguished from DDS (disc definition structure), in that TDDS is

temporary. Similarly TDFL refers to a temporary defect list, and is distinguished from a DFL (defect list) in that TDDS is temporary. Herein, both the TDFL and TDDS are included in the TDMA, and also both the TDFL and TDDS are included in the IDMA.

**[0061]** The temporary defect list (TDFL) contains (in part) a list of clusters that are determined to be defective during the use of the media. In relation thereto, TDDS specifies the format and status of the disc with relation to defect management, and in general, provides overall management information. A format of the disc may include information regarding the specific layout of areas on the disc for managing defective areas, and status of a disc may include various flags (explained below). The TDFL includes the addresses of the defective areas and the replacement areas on the BD-WO. TDDS and TDFL recorded in temporary defect management areas (for example, TDMA and IDMA), becomes permanent information (DDS and DFL) which is written in permanent defect management areas (for example DMA1-DMA4). For instance, when a disc is finalized, TDDS and TDFL are transferred and recorded in at least one of the DMAs. During the user data recording operation of the BD-WO, the TDDS and TDFL are updated periodically or at the same time and the updates are recorded in the TDMA(s) and/or the IDMA(s). The particular operation of these will become more apparent as the discussion thereof progresses.

**[0062]** In the embodiment shown in FIG.6, the TDMA is used first (before the IDMA is used) to record defect management information such

as TDDS and TDFL. When the TDMA is full, the IDMA is used to record defect management information. However, in another variation, the IDMA is used first (before the TDMA). In this case, when the IDMA is full, the TDMA is used to record the defect management information. In such an instance, information providing notification of which area among the TDMA is full is indicated by a "full flag" of TDMA. The "full flag" indication is necessary because preferred embodiments disclosed herein require information indicating which area among a plurality of TDMAs and/or IDMAS is full. In one example, this TDMA full flag may be included in TDDS.

**[0063]** Accordingly, in the embodiment of FIG.6, the TDMA and IDMA, or the IDMA and TDMA are sequentially used to store defect management information. In further embodiments, the TDMA and IDMA are located in both lead-in areas and lead-out areas. The usage of a particular TDMA and IDMA depends on a variety of factors, examples of which will be provided in a discussion of methods of using TDMA and IDMA.

**[0064]** It should be noted that the method of FIG. 6 and any other methods discussed herein (FIGS. 7-11) are applicable to the disc structures of FIGS. 4 and 5 and any other variations thereof discussed above. It should also be noted that the present invention encompasses embodiments that include a plurality of TDMAs and IDMAS on each recording layer of the BD-WO.

**[0065]** FIG. 10 illustrates an example of a full flag indicating that the TDMA and/or IDMA is full (as recorded in the TDDS) according to an embodiment of the present invention. The TDDS, as mentioned above, includes overall management information. In order to manage a defective area in the present invention, various full flags such as 'Spare Area full flag' and 'TDMA/IDMA full flag', and indicators such as 'the first PSN of latest TDFL' are used and included in the TDDS recorded in the TDMA(s) and/or IDMA(s). Particularly, a full flag provides information on whether a specific area is full and may be a 1-bit indication corresponding to the specific area. In the embodiment shown, if the specific area is a particular TDMA or IDMA of the structure, and the value of the corresponding bit of the TDMA/IDMA full flag is "1", then the corresponding area (TDMA or IDMA) is regarded as being full or in a 'full' state. Accordingly, this TDMA/IDMA can no longer be used because the TDMA/IDMA is full.

**[0066]** FIG. 10 also shows that the Spare Area full flag field includes the 8-bit structure indicated by the arrow extending therefrom. Similarly, the TDMA/IDMA full flag field (also in TDDS) includes the 8-bit structure indicated by the arrow extending therefrom. A number of bytes (size) and corresponding sectors is also indicated in the example of a field in TDDS shown in FIG. 10.

**[0067]** As one example, the bits b3, b2, b1 and b0 of the Spare Area full flag are use to indicate respectively whether or not the outer spare area OSA1, the inner spare area ISA1, the outer spare area OSAO, and

the inner spare area ISAO are full. For instance, if the Spare Area full flag has a value of 00000011, this may indicate that the inner and outer spare areas ISAO and OSAO are full. If the BD-WO is a single layer disc, then only the bits b1 and b0 may be used.

**[0068]** As another example, the bits b4-b0 of the TDMA/IDMA full flag are used to indicate respectively whether or not the IDMA in the OSA1, the IDMA in the ISA1, the IDMA in the OSAO, the TDMA in the lead-out area, and the TDMA in the lead-in area are full. For instance, if the TDMA/IDMA full flag has a value of 00000010, then this may indicate that only the TDMA in the lead-out area is full. Obviously, other examples and assignment of bit values and positions are possible for these full flags.

**[0069]** In one embodiment, the size of the TDDS is fixed, e.g., 1 cluster, and the size of the TDFL is variable in recording the TDDS and the TDFL in FIG. 6. The size of the TDFL of a dual layer BD-WO as shown in FIG. 5 can be changed from 1 cluster to 8 clusters. This size may be determined considering the capacity of an entire disc and the size of the spare area.

**[0070]** According to the method of using the TDMA/IDMA, if a defective area is created or discovered when data are recorded on a BD-WO, the data recorded or to be recorded on the defective area of the BD-WO are recorded on a predetermined area (e.g., spare area) for linear replacement in the BD-WO.

**[0071]** FIG. 7 illustrates another example of a temporary or interim defect management area usage method of the present invention. In the method of using the temporary or interim defect management area shown in FIG. 7, the TDMA and IDMA are used randomly without determining any usage order. The TDMA and IDMA full flags discussed in reference to FIG. 10 are equally applied herein.

**[0072]** If the TDMA/IDMA full flag indicates certain TDMA/IDMA is full, then a subsequent TDMA/IDMA in the BD-WO is used. In a random case such as the case shown in FIG. 7, no usage order is specified. If all the TDMA and IDMA are full, defects on the BD-WO cannot be managed any longer. When defects cannot be managed any longer, final information of TDDS and TDFL (i.e., the last updated TDDS and TDFL in the TDMA/IDMA) is transferred and recorded on at least one of the DMAs (DMA1-DMA4) to reflect the current disc status. Here, the same defect management information may be recorded in each of the DMAs so that if one DMA becomes defective, the important defect management information would not be lost. More discussion on recordation of final information on a DMA will be provided later.

**[0073]** According to the embodiment of FIG. 7, the data of a defective area are recorded on a predetermined area for linear replacement. The defect management information pertaining to this defective area and the replacement area is randomly recorded on the desired TDMA or IDMA. For example, the TDMA or IDMA nearest to the area where a defective area is located on the BD-WO is available for

recording such defect management information. Therefore, as shown in FIG. 7, the TDMA or IDMA may be used variably, or as needed.

**[0074]** In another method of using a temporary defect management area in the embodiment of FIG. 7, a plurality of defect management areas are used variably depending upon a variety of conditions. In one example, the defect management information may be recorded only on an IDMA when using the BD-WO. The latest defect management information is recorded on a TDMA later when ejecting the BD-WO. In other words, the choice of an area in which to record defect management information is determined between the area to record defect management information when using the disc and the area to record defect management information when ejecting the disc.

**[0075]** In another example, when recording data on the BD-WO, the data recorded (or to be recorded) on the defective area are recorded on the predetermined area for linear replacement if a defective area is created or discovered during the process of recording data. The defect management information is recorded on an IDMA when using the disc. The same defect management information is again recorded on the TDMA when ejecting the disc. Since the TDMA is positioned in a management area (lead-in or lead-out) of an inner track of a disc, a system first obtains information from the management area when the disc is initially loaded. The TDMA includes the latest management information even in a situation in which a previous disc has been ejected.

**[0076]** As another method of using the disc, various objects are used for selecting one of a plurality of defect management areas. One method of using the disc is based on significance. For example, when the significance to update the defect management information is low, the IDMA may be used to record the defect management information therein. When the significance to update the defect management information is high, the TDMA may be used to record the defect management information therein. Here, the criterion used to determine the significance can be set variously. The frequency of refreshing (updating) defect management information can be made conditional, or based on a designer's choice. The time to eject a disc may also be designated as a significant time in recording defect management information. In such a case, the time a disc is in use is regarded to be less significant so that during this time, the defect management information may be recorded on the IDMA. The time to eject a disc may be regarded to be more significant so that during this time, the defect management information may be recorded on the TDMA. The methods that a designer decides to use are employed discretionately.

**[0077]** One of the criteria used to determine significance is an update interval (e.g., for updating the defect management information). In other words, if the time duration between the previous update time and the present update time is long, the present update information is regarded to be relatively significant. In this case, the defect management information can be recorded on a TDMA (instead of an IDMA) even though



the disc is in use. Another criterion to determine significance is the number of defective areas created or discovered. If there are relatively many defective areas, since it is regarded that more reliability is required, defect management information may be recorded on a TDMA (instead of an IDMA) even though the disc is in use.

**[0078]** According to the objects of use, if defect management information is recorded on a TDMA according to significance, since the TDMA is positioned on the inner track, significant information can be rapidly and precisely obtained, beginning from the initial time of loading the disc.

**[0079]** FIGs. 8 and 9 illustrate examples of a temporary or interim defect management information composition method according to the embodiments of the present invention. In one embodiment, the present invention provides a method of composing and recording defect management information (TDDS and TDFL) on a TDMA or IDMA, wherein the TDDS and the TDFL are separated from each other. Another embodiment of the present invention provides a method of composing and recording defect management information on a TDMA or IDMA wherein the TDDS and the TDFL are integrated with each other. FIG. 8 shows the former case (separated) and FIG. 9 shows the latter case (integrated).

**[0080]** Particularly, FIG. 8 illustrates a method of composing and recording defect management information on a TDMA or IDMA wherein the TDDS and the TDFL are separated from each other. Each TDDS has

a fixed size, e.g., 1 cluster, and the size of each TDFL is variable from, e.g., 1 cluster to 8 clusters.

**[0081]** FIG. 9 illustrates a method of composing and recording defect management information on a TDMA or IDMA wherein the TDDS and the TDFL of the TDMA or IDMA are integrated with each other. Defect management information is recorded in the form of TDFL + TDDS as shown in FIG. 9. That is, each time the defect management information is updated, both the latest TDFL and TDDS are recorded in the TDMA or IDMA. Since the size of the TDFL can be variable from 1 cluster to 8 clusters as described above, the size of the (TDFL + TDDS) is variable from 1 cluster to 8 clusters. The methods of FIGS. 8 and 9 are applicable to each of the disc structures and TDMA/IDMA usage methods discussed in this disclosure.

**[0082]** FIG. 11 is a table representing when a DMA, a TDMA and an IDMA are used and what information each of the DMA, TDMA and IDMA has according to the objects of use. For example, the defect management information is recorded on an IDMA when using the BD-WO. The defect management information is recorded on the TDMA when ejecting the BD-WO. The defect management information is recorded on the DMA when the DMA fill-in process may occur which happens, e.g., the BD-WO is to be finalized and data is not recorded any longer, when a spare area is full, or when a TDMA or IDMA is full and defects cannot be managed any longer. The full information (e.g., full flags) is recorded in TDDS as shown in FIG. 10. If the TDMA and the IDMA are not separated according to the

objects of use, it is clear that times at which to record the defect management information on the TDMA and IDMA do not have to be distinguished from each other. The table in FIG. 11 representing when a DMA, a TDMA and an IDMA are used and what information each of the DMA, TDMA and IDMA has according to the objects of use apply to the structures discussed above, including the structures and methods shown in FIGS. 4-10, and the apparatus shown in FIG. 3.

**[0083]** In the present invention, the information to be recorded on the defective area is recorded on the area for linear replacement in the BD-WO. The defect management information is recorded on a plurality of temporary management areas provided separately on a predetermined area of the disc. The temporary management areas are divided into a temporary management area having a fixed size and a temporary management area having a variable size depending on the spare area so that defect management information can be managed more effectively.

**[0084]** It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.